



**JOINT STRIKE
FIGHTER**



Prognostics and Health Management: *The Cornerstone of Autonomic Logistics*

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JSF PO PHM Development Leads

The Next Generation Strike Fighter



JOINT STRIKE FIGHTER



VISION

**BE THE MODEL ACQUISITION PROGRAM FOR
JOINT SERVICE AND INTERNATIONAL
COOPERATION**

**DEVELOP AND PRODUCE AN AFFORDABLE
NEXT GENERATION STRIKE FIGHTER
WEAPON SYSTEM AND SUSTAIN IT
WORLDWIDE**

The Next Generation Strike Fighter



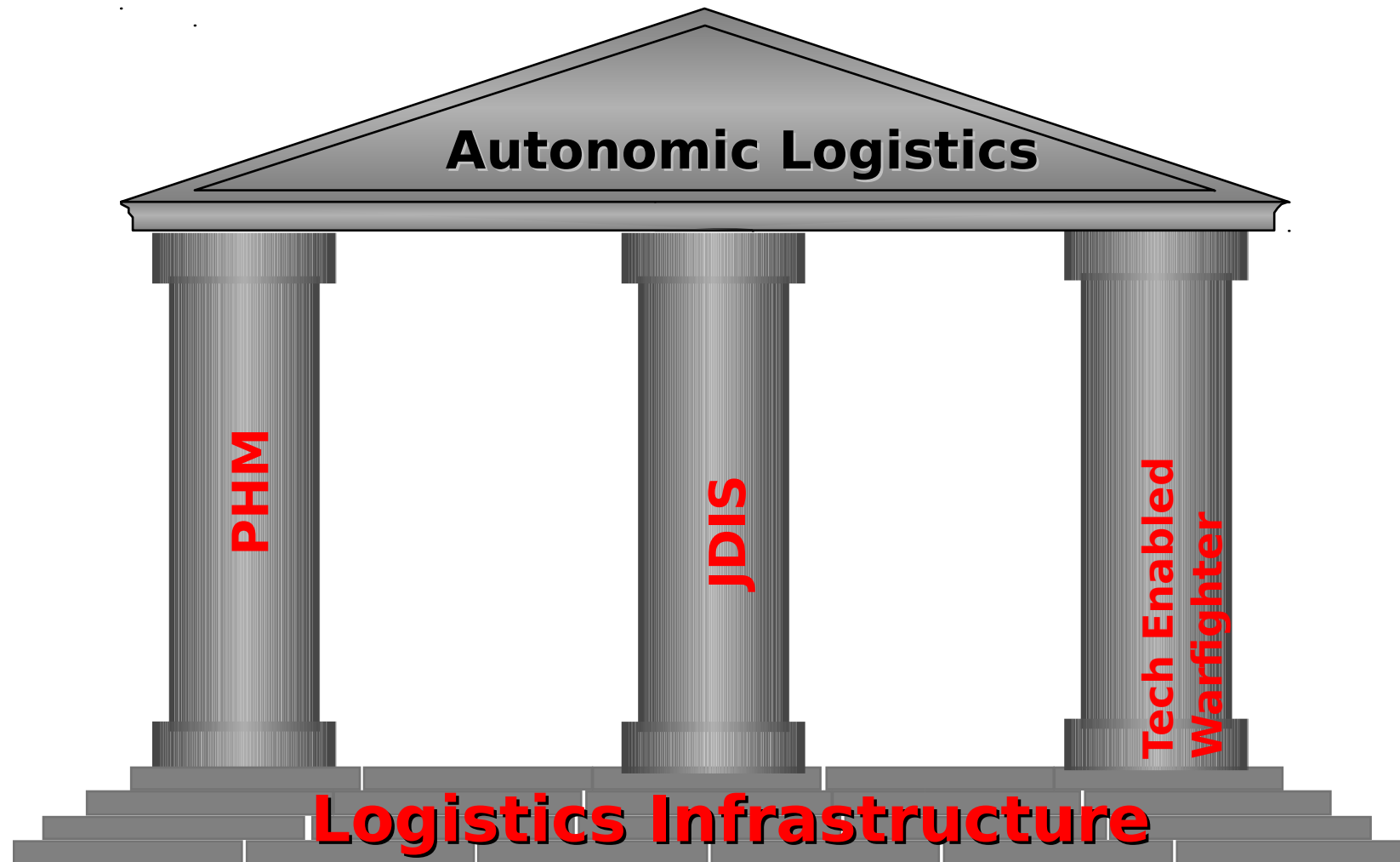
Current Logistics Structure



Too Large & Costly



Key Elements of Autonomic Logistics



Affordable, Survivable, Maintainable,

Supportable

Operationally Available and Lethal



Autonomic Logistics Structure

**Intelligent
Air Vehicle**



PHM

**Aircraft
Available**

**High
SGR**

Prognostics & Diagnostics Download

Operational Requirements

Repair Required

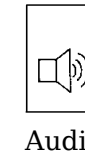
Replenishable Requirements

Onboard Stock

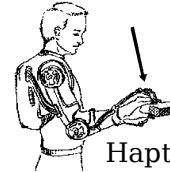


Repair Recommendation

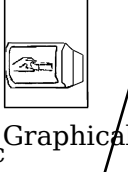
Simulated World



Audio

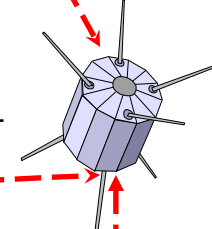


Haptic



Graphical

Maintenance Rehearsal



Integrated Supply/Engineering Info systems



Aircraft Turn-round & Repair

Return of Defective Item

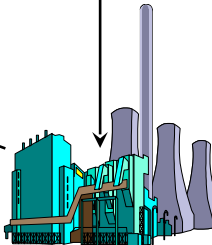
Automated Logistics Update

Lessons Learned/Failure Rates

Service/Industry Support Organization

Automatic/JIT Re-Supply

Wholesale Stockpoint



Industry

Supply of AOG item/Replenishment of Ship Stock



Prognostics and Health Management

What is it?

- **Diagnostics - is the process of determining the state of a component to perform its function(s)**
- **Prognostics - is predictive diagnostics which includes determining the remaining life or time span of proper operation of a component**
- **Health Management - is the capability to make appropriate decisions about maintenance actions based on diagnostics/prognostics information, available resources and operational demand.**

BHM turns 'Bad Actors' or 'Intermittents' into

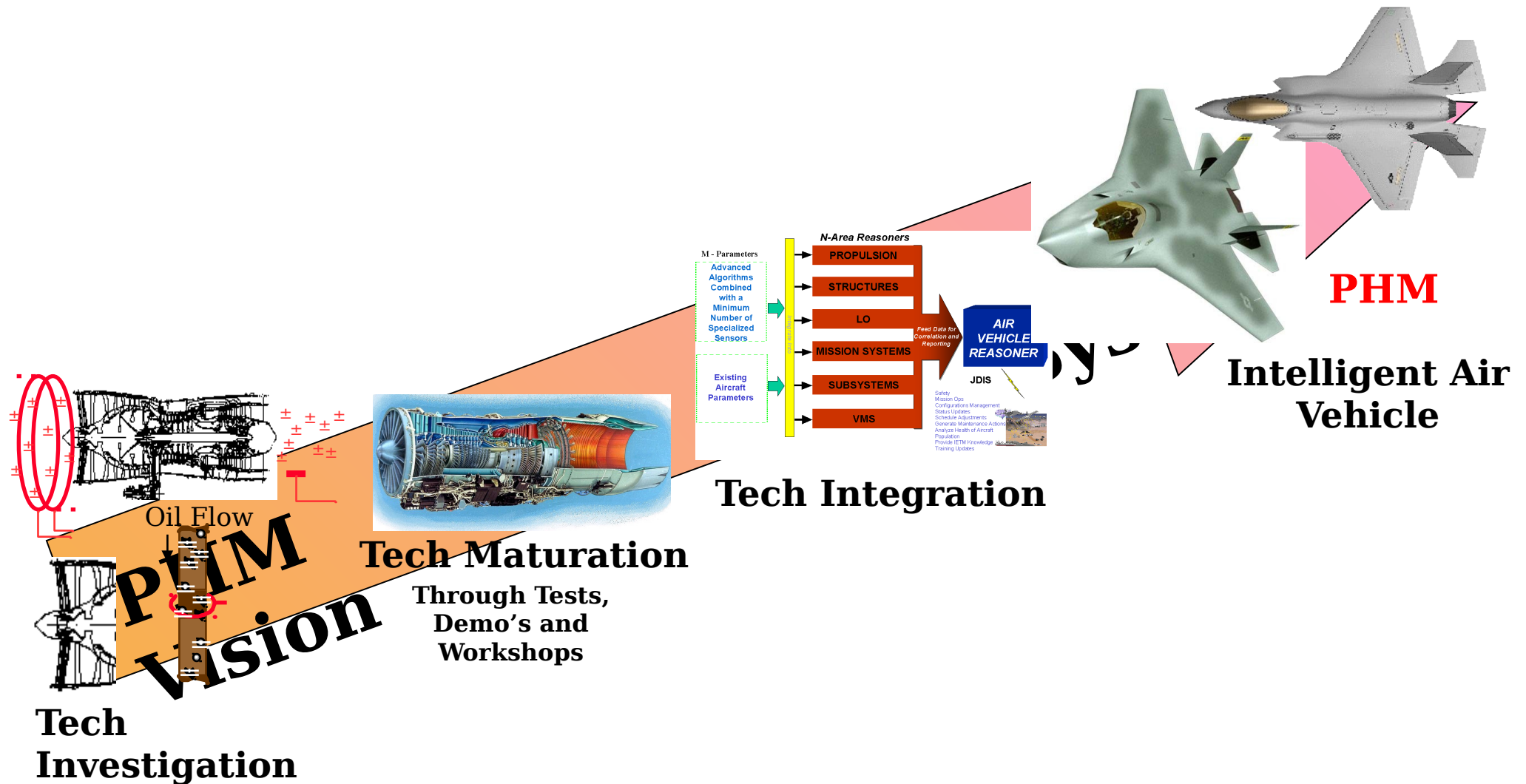


Goals of PHM

- **Enhance Mission Reliability and Aircraft Safety**
- **Reduce Maintenance Manpower, Spares, and Repair Costs**
- **Eliminate Scheduled Inspections**
- **Maximize Lead Time For Maintenance and Parts Procurement**
- **Automatically Isolate Faults to 1 LRC**
- **Eliminate CNDs and RTOKs**
- **Provide Real Time Notification of an Upcoming Maintenance Event at all Levels of the JSF Logistics Chain**



PHM Maturation Strategy



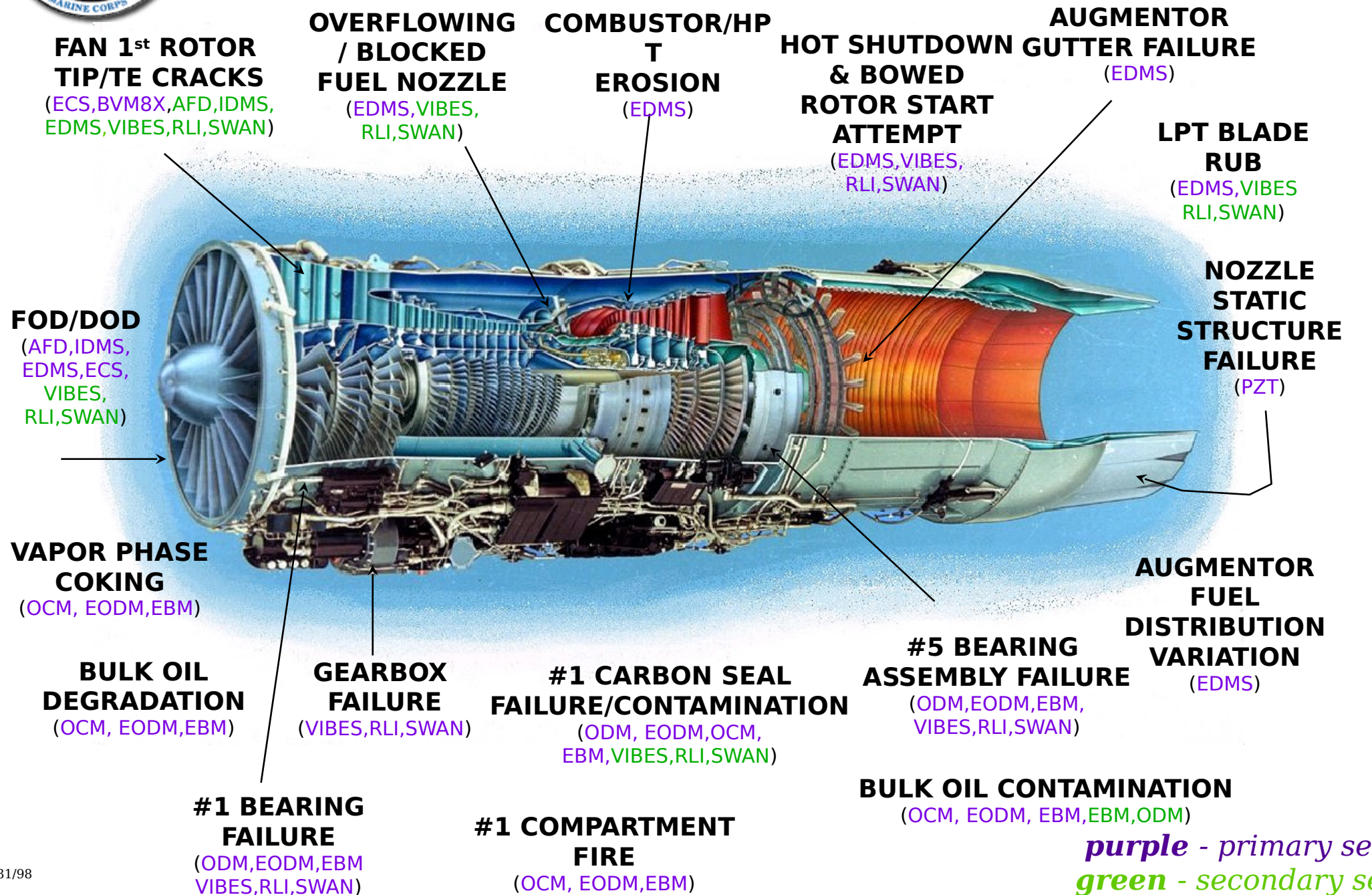


CDP PHM Accomplishments

- **Mature candidate technologies through special tests and programs**
 - SFET, Tech Maturation Efforts, Demonstrations, SBIR's, IMATE, CACE, Others....
- **PHM is designed into the air vehicle**
 - Designed down to all major subsystems
 - Architecture is well defined
- **PHM req'ts are reflected in JORD and JMS**
- **Req'ts and interface definitions defined**
- **Modeling environments developed**
- **PHM req'ts flowed to subsystem suppliers**
- **PHM maturation plans through E&MD**

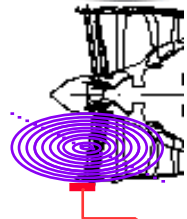


F100 SEEDED FAULT ENGINE TEST PLAN

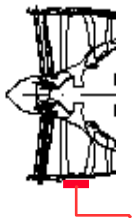




PHM Technologies Evaluated During CDP

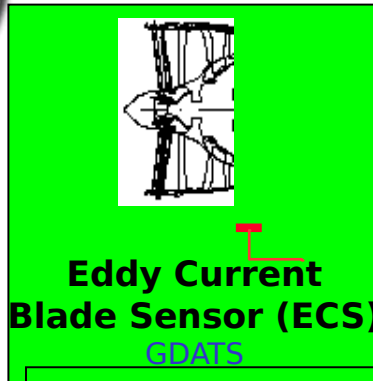


Acoustic FOD Detector (AFD)

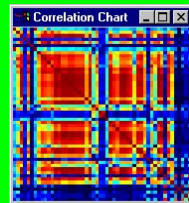


Blade Vibration Meter (BVM8X)

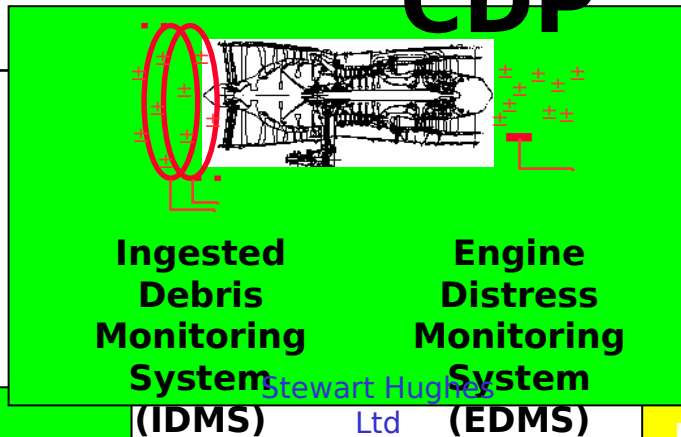
Hood Technology



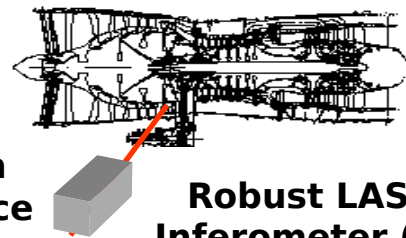
Eddy Current Blade Sensor (ECS)
GDATS



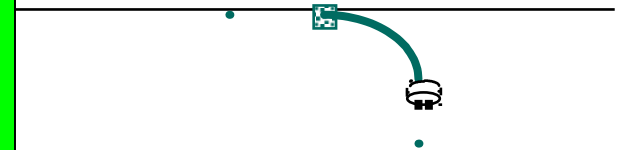
Beacon-Based Exception Analysis for Maintenance (BEAM)
JPL



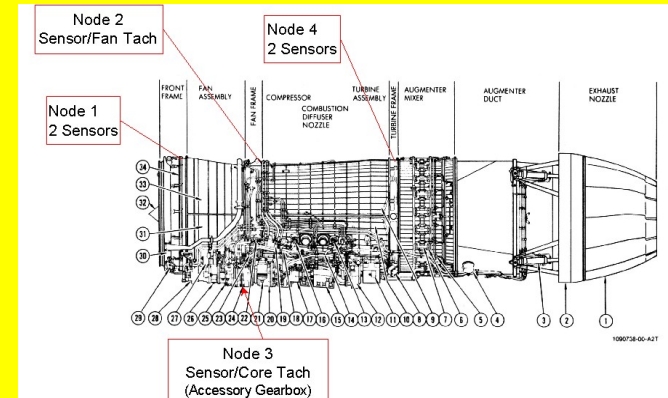
Ingested Debris Monitoring System (IDMS)
Stewart Hughes Ltd



Robust LASER Interferometer (RLI)
Epoch Engineering

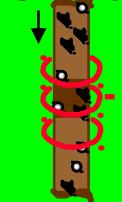


Piezoceramic Patch Crack Detection (PZT)
UTRC

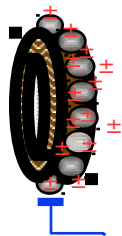


MEMS Sensors

Oil Flow

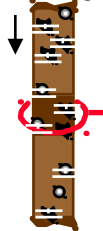


F119 Oil Debris Monitor (ODM)
GasTOPS



Electrostatic Bearing Monitor (EBM)
ExperTech

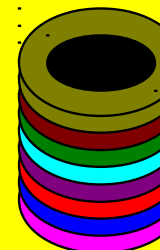
Oil Flow



Electrostatic Oil Debris Monitor (EODM)
ExperTech/SHL

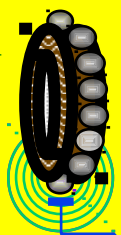


Oil Condition Monitor (OCM)
UDRI



ICHM

Communications
Diagnostic Processor
General Purpose Processing
Signal Processing
Signal
Power Interface/Generation
Sensing
Self calibration/Active Cancellation



Stress Wave Analysis (SWAN)
DME



PHM Design Impacts

- **PHM Architecture Significantly Improves Performance**
 - Increased fault detection/Fault Isolation
 - Reduces Ambiguities, Reduce False Alarms, Enables Use of Existing Sensors
- **PHM Has Influenced Virtually All Aircraft System Designs**
 - PHM Architecture Design Enables a Comprehensive Approach and Significant Growth Potential
 - Improve Accuracy & Fault Detection/Fault Isolation,
 - Incorporated Proven Demonstrated Technologies
 - Taken Advantage of Existing Parameters and Sensors; Minimal Weight/Cost Impacts
 - Takes Advantage of Advances in S/W Algorithms and Processing Technology, Reasoners, and a Few New Sensor Technologies
- **PHM Is One of the More Significant Integration Tasks**
 - Enhances the Influence of Supportability Impacts of Design
- **Boarded PHM Technologies Have Been Demonstrated, Tested, or Analyzed/Assessed as Low-Risk**
- **PHM Program Shows Potential For Significant Operational and Support Benefits**
 - Cost Benefit Analyses Defined Very Significant Savings
 - All Capabilities have to “buy their way on”

***PHM Technologies Integrated Into the Design
Ensure A Capable, Affordable, Low-Risk Solution***



PHM Redefines Design Criteria

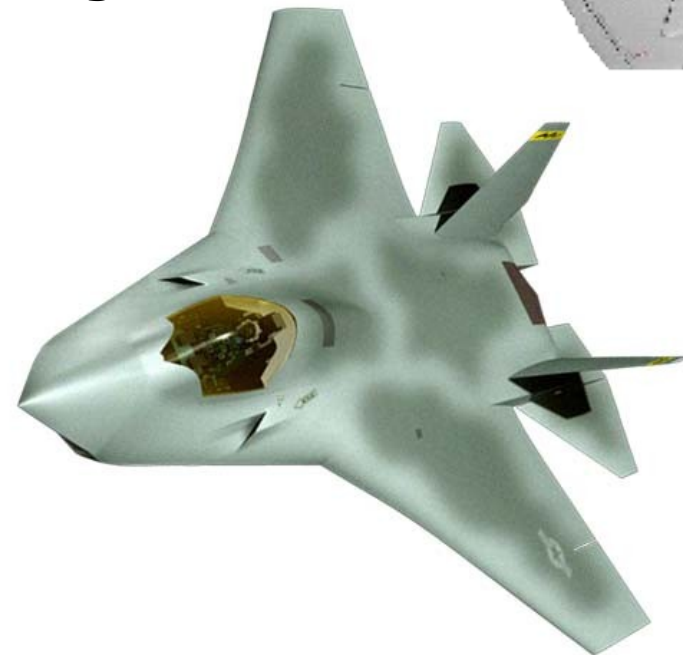
- **Old**
 - **Safety and Supportability are a Function of Reliability, Redundancy, and the Support Concept ~ *Ensures***
- **New**
 - **Safety and Supportability are a Function of Reliability, Redundancy, **PHM Capabilities**, and the New Support Concept ~ *Drives***

Autonomic Logistics Enables a Paradigm Shift



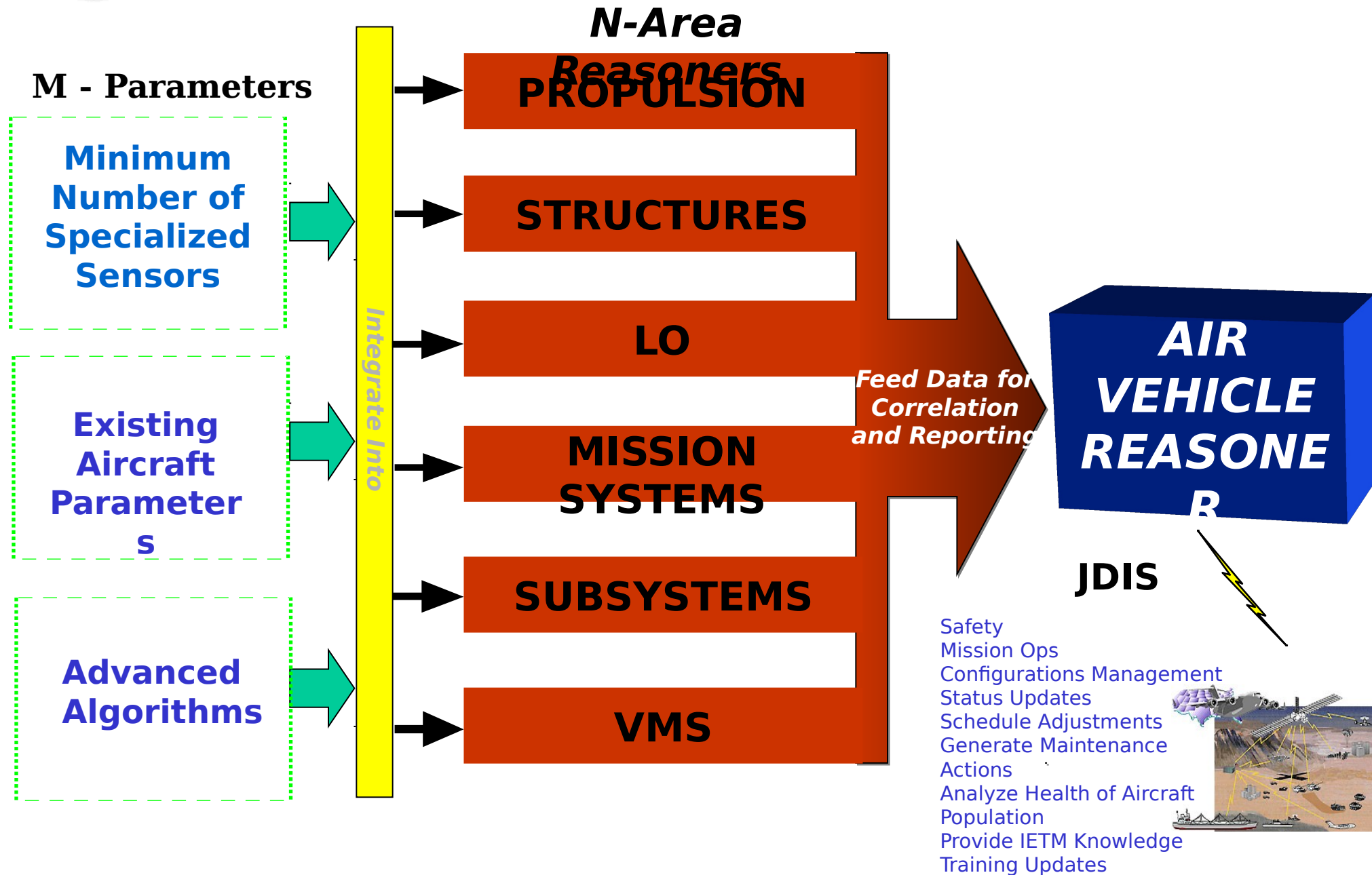
PHM is Designed into the Air Vehicle

- **Reflected in JORD and JMS Requirements**
- **Reaches across the entire airframe**
 - **Mission Systems**
 - **FD/FI - In flight reconfiguration**
 - **Structures**
 - **Signature**
 - **Propulsion**
 - **Dual engine safety with single engine**
 - **VMS**
 - **Electronics Prognostics**
 - **Subsystems**
 - **Hydraulics**
 - **Fuel System**
 - **Electric Power System**
 - **APU**
 - **Drive Shafts**
 - **Etc...**





PHM Architecture



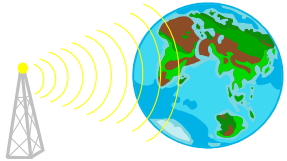


E&MD Products

- **Fully Functional PHM System at Initial Fleet Introduction**
- **Comprehensive PHM Capability on All Major Subsystems**
- **Demo's, Validated and Verified PHM Capabilities**
- **On-board PHM Hardware and Software Architectures Fully Integrated with the Aircraft Design**
- **Off-Board PHM Seamlessly Integrated with JDIS and On-Board PHM**
- **Any Appropriate Advanced Technologies Fully Capable and Prepared for Eventual Insertion at the Proper Time**



JOINT DISTRIBUTED INFORMATION SYSTEM (JDIS)

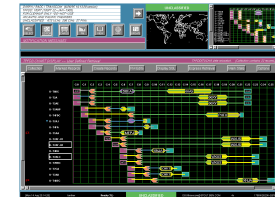
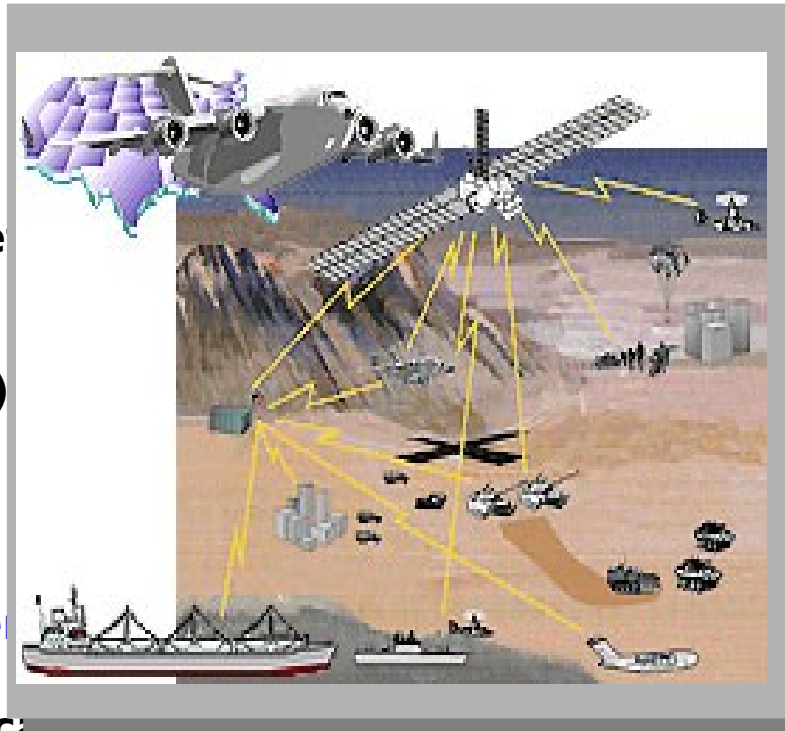


Communications

- Web enabled
- Radio Frequency
- Infrared/Ultraviolet
- SATCOM
- Databurst Mayday (Black Box Data)

Maintenance Management

- Web Interfaces
- Maintainer Identification
- Automatic Record of repairs
- Compatibility with legacy systems



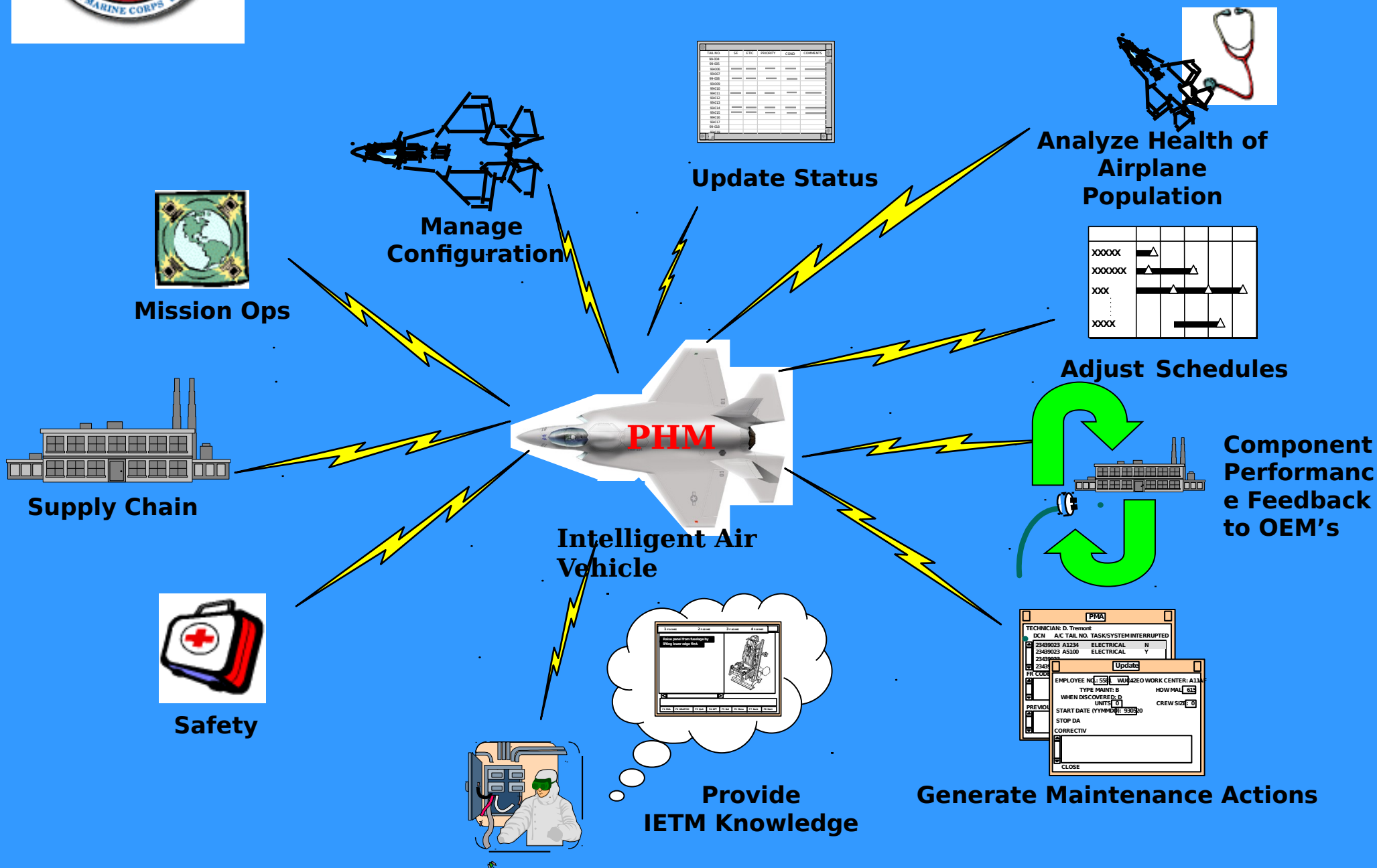
Database Management

- Safety
- Mission Ops
- Configuration Management
- Status Updates
- Schedule Adjustments
- General Maintenance Actions
- Analyze Health of Aircraft
- Population
- Provide Interactive Electronic Technical Manual (IETM) Knowledge

Intelligent, Connected Logistics Infrastructure

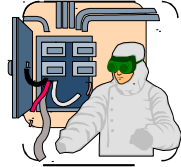


JDIS FUNCTIONALITY





Technologically Enabled Warfighter



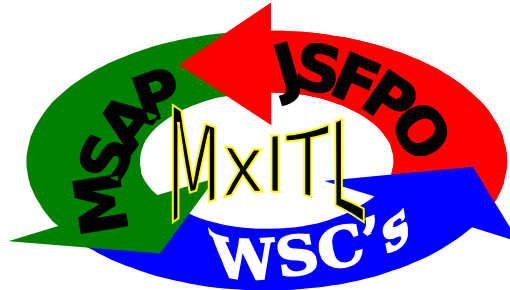
Training Continuum
**Distributed Simulation/
Mission rehearsal**



**Virtual Reality Haptic
Feedback**



**Interactive Electronic
Technical Manuals**



Maintainer in the Loop



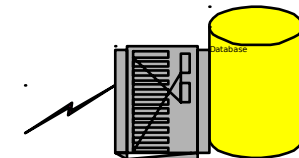
**Embedded
Simulation**



**Electronic
Classroom**



On-Line Support



**On-Line Maintenance
Technical Manuals**

Technician Enhanced With Technology



AUTONOMIC LOGISTICS SUMMARY

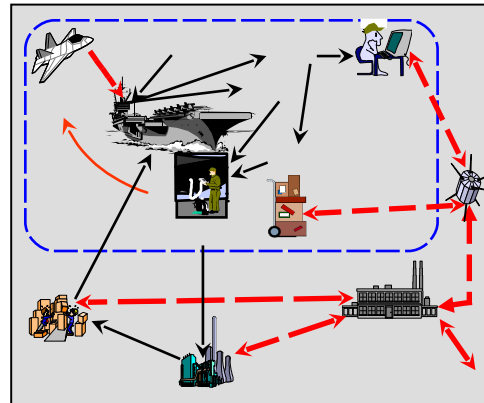


PHM

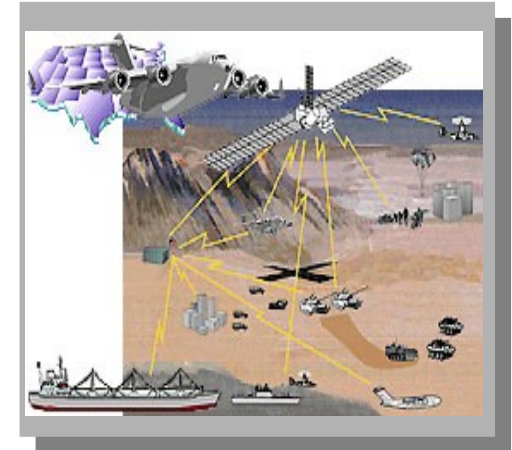
**Intelligent Air
Vehicle**



**Technologically Enabled
Warfighter**



Autonomic Logistics



**Joint Distributed
Information
System**

By 2020, the JSF will comprise 75% of US Tactical Aircraft

Affordability is the only option

AUTONOMIC LOGISTICS WILL DELIVER



JOINT STRIKE FIGHTER



JSF CHALLENGE

AFFORDABLY MEET THE REQUIREMENTS
OF THE WARFIGHTER

The Next Generation Strike Fighter